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Virtual Wireless Sensor Networks

using Cloud-computing

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***Abstract*— A sensor is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or an electronic instrument. In modern world, billions of physical sensors are used for various purposes. Applications include cars, machine, aerospace, medicine, manufacturing and robotics. The emerging field of wireless sensor networks combines sensing, computation and communication into a single device. The power of wireless sensor networks lies in the ability to deploy large number of tiny nodes that assemble and configure themselves. This paper assumes that the immense power of cloud can only be fully exploited if it is impeccably integrated into our physical lives.**

Keywords- Wireless Sensor Network Architecture; Sensor-Cloud Computing; Sensor-cloud architecture; WSN Architecture; Applications of Sensor-cloud.

I. INTRODUCTION

With recent advances in wireless communication, processor, memory radio, low power, highly integrated digital electronics and micro electro mechanical systems(MEMS), it becomes possible to significantly develop tiny and small, low power, low cost multi-functional sensor nodes. Wireless Sensor Networks (WSN) is a self-organizing network consisting of a lot of sensor devices. These sensor devices connect to others through wireless communication channel in a multi-loop manner. Wireless grid is a wireless network based virtual system that consists of wireless-connected different types of electronic devices and computers. The wireless sensor grid integrates wireless sensor networks and traditional grid computing technologies. The applications are designed around the data from the sensors. With the new computing paradigm of cloud computing adopted in the market, we can foresee the future demands on the sensor based services remotely via cloud. Sensor cloud computing is a heterogeneous computing environment in which there are potentially tens of thousands of deployed sensors. The sensor-cloud provisions the use of physical sensors through the virtualization of sensing services. Sensor-cloud is particularly attractive as it can change the computer paradigm of wireless sensor networks. Sensor-cloud computing surpasses traditional wireless sensor networks in many aspects. In sensor-cloud computing network, users need not own sensors. They can simply rent the sensing services.

This considerably reduces the cost of ownership enabling the usage of large-scale sensor networks affordable. One physical sensor can be projected as multiple virtual sensors and vice-versa.

In this paper, we propose a novel architecture based on cloud computing for wireless sensor networks as well as system architecture for sensor networks. The working of sensor networks integrated with cloud computing networks is explained in below sections. The rest of the paper is organized as follows: In section II, we present the system architecture for sensor networks. In section III, we outline our new architecture based on cloud computing. In section IV, we present various applications using the sensor-cloud network, followed by section V in which, we give a brief discussion on challenges that will be faced in developing the sensor cloud. Finally, we outline our conclusions and highlight some recommendations and directions for future work in the last section.

II. SYSTEM ARCHITECTURE FOR WIRELESS SENSOR NETWORKS

Most common architecture for wireless sensor networks follows the OSI model. Basically in sensor networks, we need five layers: application layer, transport layer, network layer, data link layer and physical layer. Added to the five layers are the three cross plane layers as shown in Fig.1.

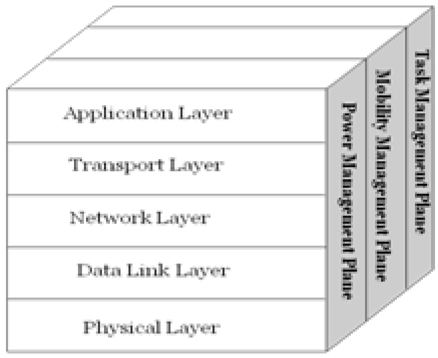

Figure 1. System architecture of WSN

The three cross layers or planes are; power management plane, mobility management plane, and task management plane. These layers are used to manage the network and make the sensors work together in order to increase the efficiency of the network. These vertical layers provide cross-functionalities as a set of interfaces, which can be used by all of the network layers.

Communication in sensor networks is classified broadly into two parts- data and control messages. These planes are

used in the reliable data transmission of control messages. The transport layer provides reliable transmission of message, congestion control, and flow control. Routing of data and control messages takes place at the Network layer. The basic idea of routing protocol is is to define a reliable path and redundant paths according to a certain scale. The Data layer is responsible for multiplexing data streams, data frame selection and error control. The physical layer is can provide an interface to transmit a stream of bits over physical medium. Lastly, the Application layer is responsible for traffic management and provides software for different applications that translate the data in an understandable form or send queries to obtain certain information.

III. Cloud Computing Based Architecture

The architecture is as shown in Fig. 2. A number of nodes, called the sink points, are distributed across the WSN area, constitute a cloud. This type of node can be referred as "cloud-node", which is equipped with more resources. Furthermore, a cloud node acts as a sink for sensors nearby. Therefore, the architecture is naturally cluster based. A cluster can be referred to as a "zone" here rather than calling it a cluster as in traditional WSN. These sensor nodes in a zone are organized as independent Local Wireless Sensor Networks (LSWNs), and all LSWN are integrated together by the cloud. The cloud can be viewed as a "virtual sink" for whole sensor network.

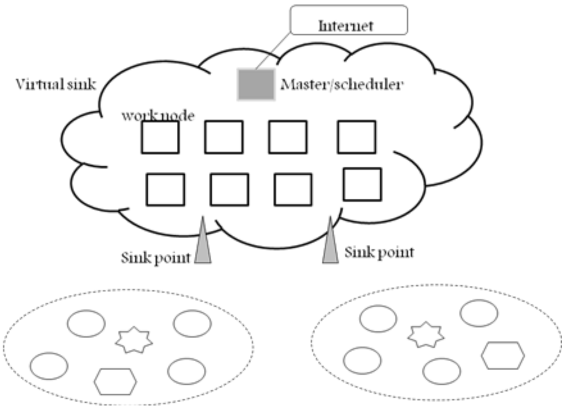

Figure 2. Cloud Computing based WSN architecture

There are a number of physical sensors scattered around the environment which may be left unused once. These physical sensors are combined efficiently in order to create network of sensors which may include several number and different type of sensors. These networked sensors are then allowed to create service templates by classifying the different type of sensors in accordance to their reading provided. Service templates are created to generate service instances once they moved to cloud-sensors platform means these physical sensors are going to be virtualized using cloud computing, through the basis of sensor service templates.

Since the cloud computing enables the physical sensors to be virtualized, the users of the sensor cloud infrastructure need not worry about the status of their connected sensors (i.e., whether fault tolerant or not), but they should concern only with the status of their virtual sensors. In sensor-cloud architecture, sensors owners are free to register or unregister their wireless sensors. The sensors, database servers, processors and sensor devices are then set to become operational. After that templates are created for generating the service instances (virtual sensors) and its groups, once templates are prepared then these virtual sensors are able to share the related and continuous sensors to receive quality data. Users then request these virtual sensors by choosing the appropriate service templates use their service instances (virtual sensors) after being provisioned and discharge them when become useless.

One of the most important factors while considering the organization of nodes is the bandwidth, especially when they communicate through wireless channel. The cloud here is organized in the Hadoop way. Hadoop aims for big data storage and process, and data movement reduction is one of its design goals. Both storage system of Hadoop, Hadoop distributed File System (HDFS) and data processing system (Map Reduce framework) has master/slave architecture in which master is responsible for storing file meta-data or scheduling jobs, and slaves are responsible for storing file content or task execution. The two masters could be deployed either in the same physical node or in different physical nodes. In its storage system, when a client accesses a file, it firstly contacts the master to retrieve the file's Meta data, and then it directly retrieves the content from the slaves which store a part of file data. In data processing system, the code used is submitted to the master, and then the master distributes the cod to the slaves which stores the processed data. Hadoop supports data compression mechanism to reduce bandwidth cost as much as possible. Therefore, in the architecture the cloud node is not only the slave of Hadoop cloud, but also the sink point of a zone. It receives the data sent by the sensors in the zone, and acts as a client to store these data into Hadoop.

IV. Applications

Integration of Wireless Sebnsor Networks with cloud is for ease of sharing and analyzing real time sensor data on fly. The sensor nodes inherent the property of sensing as a service to trigger the events over the internet adds advantages to the sensor-cloud. Some of the real time applications are transport monitoring, weather forecasting, military use, health care and so forth.

A sensor is any source or sink of time series. In the thin client era, smart phones, kindles, tablets, kinetics, web-cams; robots, distributed instruments such as environmental measures are sensors. Sensors being intrinsically distributed are grids. However natural implementations use cloud to consolidate, control and collaborate with sensors. Sensors are typically small and have pleasingly parallel cloud implementations.

Some applications of the sensor network using cloud are explained below:

A. *Transport Monitoring*

In transport monitoring systems, sensors are used to detect vehicles and control traffic lights. Video cameras are also used to monitor road segments with heavy traffic and the videos are sent to human operators at central locations. Sensors with embedded networking capability can be deployed at every road intersection to detect and count vehicle traffic and estimate its speed. The sensors will communicate with the neighboring nodes to eventually develop a "global traffic picture" which can be queried by users to generate control signals. Data from sensors is acquired and transmitted for central fusion and processing. This data can be used in variety of applications

such as- vehicle classification, parking guidance and information system.

B. *Weather forecasting*

Weather forecasting is the application to predict the state of the atmosphere for a future time and a given location. Weather monitoring and forecasting systems typically includes- Data collection, Data assimilation`, Numerical prediction and Forecast presentation. Each weather station is equipped with sensors to sense the data. The data collected from these sensors is huge in size and difficult to maintain using the traditional database approaches, and assimilation is done. The complied equations govern how the state of atmosphere changes.

C. *Military Use*

Sensor networks are used in military for monitoring friendly forces, equipment and ammunition, reconnaissance of opposing forces. The data collected from these applications are of greatest importance and needs top level security which may not be provided by using normal internet connectivity. Cloud computing is one of the solution for this problem by providing a secure infrastructure exclusively for military applications.

D. *Health Care*

Sensor networks are also widely used in health care area. The data collected from the patients are very sensitive and should be maintained properly as collected data are required by doctors for their future diagnosis. In traditional approach, the patient's history database is maintained in the local nursing home. Doctors can only make diagnosis when they will visit the particular nursing home. This problem can be overcome by forming a cloud where the critical data of the patient can be maintained.

V. CHALLENGES IN DEVELOPING SENSOR NETWORKS USING CLOUD

Wireless micro sensor networks have been identified as one of the most important technology in 21st century. Technical challenges in sensor network development include network discovery, control and routing, collaborative signal and information processing, tasking & querying and security. The paper concludes by presenting some recent research results in sensor network algorithms, including localized algorithms and directed diffusion, distributed tracking in wireless ad hoc networks, and distributed classification using local agents.

The challenge of developing wireless sensor applications is not limited to deploying reliable wireless communication. Power management is an even bigger challenge. The real benefit in wireless communication is primarily to avoid the wiring cost, so data cables as well as the power cable need to be eliminated. The biggest technical challenge for developing ultra low power sensor networks is managing the energy consumption without reducing the range or functionality, like speed and standard compliance. The resulting elimination of battery replacement will then simplify maintenance and provide a higher level of use and safety.

It is obvious that current consumption-milli amps- and duty cycling are important in wireless sensor networks. However, minimizing current consumption is only one part of the solution. Five other essential issues are key to developing the low-power wireless sensor applications, the first of which is low power Wireless mesh routing.

One of the most dramatic differences between wireless sensor communication technology and other well-known wireless technologies is the ability of the sensor node to forward messages from other nodes further down a communication channel. This is called mesh routing or multi – hop networking. Mesh networking is one of the effective and reliable solutions for spanning large infrastructures beyond the range of what a single wireless link can do.

The conflicts of the environment can lead to collection of improper data. Security threats from hackers can inject malware into physical sensors upon having an access. The data in the raw or processed form can be stolen or tampered on cloud. Infected client can cause security breaches to the sensor-cloud system. The communication channels between the client, sensors and cloud are vulnerable to side-channel information leak.

Sensor owners allow the cloud computing service to use their sensor devices similar to IT resource owners. Sensors are the costly devices and the maintenance of the battery driven sensor is quite high, with this sharing through cloud sensor provide can effectively maintain the cost with the rent generated with various applications sharing the devices.

VI. CONCLUSION

The communication among sensor networks using internet is a challenging task because sensor networks contain limited bandwidth, memories and small size batteries. The issues of storage capacity can be overcome by widely used cloud computing technologies. This paper proposes an extensible architecture for integrating the wireless sensor networks with the cloud. The scope of sensor-cloud is thus in line with the recent advanced applications of WSN architecture using sensor-cloud.

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